PROTECTION SPRAYING AGAINST SPRUCE BUDWORM IN NEW BRUNSWICK

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PROTECTION SPRAYING AGAINST SPRUCE BUDWORM

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SUMMARY

In 1988, Forest Protection Limited (FPL) applied insecticides aerially to 448 500 ha of spruce budworm (Choristoneura fumiferana (Clem.) infested forest land in New Brunswick. This represents a 6.3% decrease from the 478 300 ha treated in 1987. In addition J.D. Irving Limited treated about 98 000 ha of its own freehold land (compared to 105 000 ha in 1987).

Of the total area treated by FPL, 51.5% received a double application of the chemical fenitrothion (Sumithion) and 1.4% received a single application. About 47.0% of the area received a single treatment of bacterial insecticide, Bacillus thuringiensis var. kurstaki (B.t.)in the form of two products, viz. Futura XLV (41.2%) and Dipel 132 (5.8%). This was the largest operational use (area and proportion) of B.t. in any of the spray programs in New Brunswick to date.

Spray aircraft included 12 TBMs, 1 four-engine DC-6 and 2 single-engine agricultural-type small spray planes (SSPs). TBMs were used to treat about 58% of the total area and the DC-6 treated about 41% of the area. The Dipel 132 was sprayed by TBMs, and the Futura XLV sprayed primarily by the DC-6.

Objectives of the program were to limit budworm defoliation and retain 60% or more of the current year's needles on balsam fir (Abies balsamea (L.) Mill.) and 50% or more on red-black spruce (Picea rubens Sarg.-P. mariana (Mill.) B.S.P.). Although there was some protection due to B.t. treatment, results were far superior with fenitrothion. Budworm mortality due to fenitrothion averaged 72%, compared to 50% for B.t. Branch defoliation in fenitrothion plots averaged only 34%, but was 68% in B.t. plots. The average percent reduction in defoliation was 61% for fenitrothion compared to 24% for B.t. Only 19% of the fenitrothion area had moderate and severe defoliation compared with 60% of the B.t. area. The area of moderate and severe defoliation in areas sprayed with fenitrothion is close to the previous 11-year average of 14% (range 6% to 20%) in programs based almost solely on chemical treatments. Some of the factors which could have influenced these results are briefly discussed. A brief comparison is made with similar high population data from Quebec's 1988 program.

The aerial defoliation survey detected an estimated 43 000 ha of light, 196 000 ha of moderate, and 304 000 ha of severe defoliation. Approximately 65.5% of the provincial moderate and severe defoliation occurred outside the treatment areas. Moderate and severe defoliation was detected on 38.5% of the total treated area in proportions noted above.

Results of the L2 survey indicate a 10% increase in extent of infestation with some lessening in its intensity. For 1989, it is forecast that 1.65 million ha of forest land will contain variable, and moderate to high populations of budworm, primarily across the northern quarter of the Province, but with some large patches elsewhere. No significant damage is expected in the southern half of the province or throughout most of the western and eastern areas, continuing the low trend of the past few years in these areas.

RÉSUMÉ

En 1988, Forest Protection Limited (FPL) a effectué au Nouveau-Brunswick l'épandage d'insecticides, par voie aérienne, sur une superficie de 448 500 hectares de terres forestières infestés par la tordeuse du bourgeon de l'épinette (Choristoneura fumiferana (Clem.)). La superficie ainsi traitée est de 6,3 % inférieure aux 478 300 hectares traités en 1987. En outre, J. D. Irving Limited a traité environ 98 000 hectares de ses terres en tenure libre, comparativement aux 105 000 hectares de superficie traités en 1987.

De la superficie totale traitée par FPL, 51,5 % ont reçu deux applications de Fénitrothion (Sumithion) et 1,4 % une seule application. Environ 47 % de la superficie ont reçu une application simple d'un insecticide bactériologique, Bacillus thuringiensis var. kurstaki (B.t.), sous la forme de deux produits, soit viz. Futura XLV (41,2 %) et Dipel 132 (5,8 %). Il s'agissait de l'opération d'application la plus importante (tant pour ce qui est de la superficie que de la quantité) de B.t. dans le cadre d'un programme de pulvérisation au Nouveau-Brunswick jusqu'à ce jour.

Les appareils utilisés pour l'épandage comprenaient 12 TBM, un quadrimoteur DC-6 et deux petits appareils épandeurs (PAÉ) monomoteurs, du même type que ceux utilisés pour l'agriculture. Les TBM ont couvert environ 58 % de la superficie totale et le DC-6 a permis de traiter environ 41 % de celle-ci. Le Dipel 132 a été pulvérisé par les TBM, tandis que le Futura XLV a été pulvérisé surtout par le DC-6.

Ce programme avait pour but de limiter la défeuillaison provoquée par la tordeuse du bourgeon de l'épinette et de préserver 60 % ou plus des aiguilles de l'année sur le sapin baumier (Abies balsamea (L.) Mill.) et 50 % ou plus des aiguilles sur l'épinette rouge/noire (Picea rubens Sarg.-P. mariana (Mill.) B.S.P.). Bien que le traitement au B.t. ait donné certains résultats, ceux que l'on a obtenus à l'aide du Fénitrothion ont été nettement supérieurs. L'élimination de la tordeuse attribuable au Fénitrothion atteignait en moyenne 72 %, en regard de 50 % pour le B.t. La défeuillaison des branches dans les blocs traités au Fénitrothion atteignait en moyenne 34 % seulement, contre 68 % dans le cas des blocs traités au B.t. La réduction moyenne de la défeuillaison s'est établie à 61 % dans le cas du Fénitrothion par comparaison à 24 % pour le B.t. Dix-neuf pour cent seulement de la superficie traitée au Fénitrothion présentaient une défeuillaison modérée et grave, comparativement à 60 % pour la superficie traitée au B.t. La superficie de défeuillaison modérée et grave dans le cas des blocs pulvérisés au Fénitrothion s'approche de la moyenne des onze années antérieures, soit 14 % (variation de 6 % à 20 %), obtenue dans le cadre de programmes reposant presque uniquement sur le traitement à l'aide de produits chimiques. Nous abordons brièvement certains des facteurs susceptibles d'avoir contribué à ces résultats. Nous faisons également une brève comparaison avec des données sur des infestations d'intensité semblable dans le cadre du programme québécois de 1988.

Le relevé aérien de la défeuillaison a permis de déceler une défeuillaison légère, modérée et grave couvrant respectivement environ 43 000, 196 000 et 304 000 hectares. Environ 65,5 % de la défeuillaison modérée et grave dans la province s'est produite à l'extérieur des superficies traitées. On a décélé une défeuillaison modérée et grave sur 38,5 % de la superficie totale traitée de la façon décrite ci-dessus.

Les résultats du relevé L2 ont indiqué une augmentation de 10 % de l'ampleur de l'infestation, accompagnée toutefois d'une certaine diminution de son intensité. On prévoit pour 1989 l'infestation d'une étendue de 1,65 million d'hectares de terres forestières par des populations variables de tordeuse du bourgeon de l'épinette, cette infestation étant de niveau modéré à grave. On prévoit que ce sont surtout les régions du nord de la province qui seront touchées, bien que d'importantes concentrations sont également prévues ailleurs. On ne prévoit aucun dommage important dans le sud de la province, ni dans la plupart des régions de l'ouest et de l'est, ce qui confirme encore la tendance à la baisse observée au cours des dernières années dans ces régions.

5. *CONCLUSIONS*

5.1 *Opérations d'arrosage*

1. Les opérations de pulvérisation d'insecticides chimiques et biologiques en 1988 onto été effectuées dans la période prescrite pour les pulvérisations larvaires.

2. Aucune zone n'a été privée de traitement en raison de retards causés par le mauvais temps.

5.2 *Efficacité du programme*

1. D'après les évaluations effectuées sur la défoliation actuelle d'un échantillon de branches, le fénitrothion a donné avec régularité des résultats acceptables en 1988, alors que ce n'est pas le cas pour le B.t.

2. Les résultats d'une étude aérienne de la défoliation révèlent que la défoliation était tantôt modérée tantôt élevée sur une superficie de 500 000 hectares, dont 34,5 % se trouvaient dans la région ayant fait l'objet du traitement; c'est-à-dire, 19,3 % de la région traitée au fénitrothion et 60,1 % de la région traitée au B.t. Soixante-cinq virgule cinq pour cent de la défoliation variant de modérée à élevée notée dans la province se trouvait à l'extérieur des régions traitées, et ce, principalement dans les régions où l'on avait anticipé cette défoliation.

3. Dans les parcelles d'essai traitées au fénitrothion, la défoliation moyenne actuelle des échantillons de branches de sapin baumier était de 34 % en comparaison de 68 % dans les parcelles d'essai traitées au B.t.

4. Dans les parcelles d'essai traitées au fénitrothion, la défoliation anticipée des branches de sapins baumiers a été réduite en moyenne de 61 %, en comparaison de 24 % dans les parcelles traitées au B.t.

5. Bien qu'il ne s'agisse pas d'une mesure de l'efficacité, l'élimination moyenne attribuable au Fénitrothion s'établissait a 72 %, en regard de 50 % dans le cas du B.t.

6. On ignore jusqu'à quel point les résultats médiocres obtenus avec le B.t. peuvent être attribuables aux dépôts (non mesurés), au temps froid qui a sévé pendant la période d'arrosage ou à d'autres facteurs comme les variables reliées aux insectes et aux porteurs dans les grands blocs d'arrosage, et enfin, l'application unique du B.t., compte tenu de son mode unique d'action. Tous ces facteurs ont sans doute contribué à ces résultats à divers degrés.

7. Une comparaison des données obtenues au Québec en 1987 et en 1988 appuie la conclusion selon laquelle le B.t. a été inefficace dans ces deux provinces, dans les régions où la population de larves était élevée (plus de 20 larves par branche).

5.3 Prévisions

1. Selon l'étude L2, on prévoit une augmentation de l'infestation de l'ordre de 10 % en 1989. On prévoit qu'une superficie de 1,653 millions d'hectares sera touchée par des populations de tordeuses du bourgeon de l'épinette variables ou de modérées à élevées. Cette augmentation mineure suit la diminution enregistrée au cours des quelques dernières années. La région touchée par les prévisions représente environ 23 % de la superficie totale de la province.

2. Une diminution apparente de l'intensité des infestations a été décelée par une diminution de la proportion de points L2 échantillonnés cette année dans le comté de Restigouche.

3. On ne prévoit aucun dommage important en 1989 dans le sud de la province, ni dans la plus grande partie de l'ouest et de l'est.

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PROTECTION SPRAYING AGAINST SPRUCE BUDWORM IN NEW BRUNSWICK IN 1988

In 1988, selected spruce budworm infested forests were aerially treated for foliage protection in New Brunswick. Both chemical and biological insecticides were used. Operational information may be found in the "1988 PROGRAM REPORT" prepared by Forest Protection Limited (Irving, 1988). This year was the largest operational use of B.t. in New Brunswick's spruce budworm spray programs to date. This report outlines the program and evaluates various treatments in terms of stated foliage protection objectives. A forecast of infestation for 1989 is presented.

1. THE SPRAY OPERATION

1.1 Area Sprayed

In 1988, spray was applied to 448 500 ha of forested land (Table 1; Figure 1) slightly less than the 478 300 ha treated in 1987 (Carter and Lavigne, 1988). Spray logistics were planned and implemented by Forest Protection Limited (FPL). In addition, Forest Patrol Limited (J.D. Irving Ltd.) sprayed approximately 98 000 ha of J.D. Irving Ltd. freehold land, (B. Brunsdon, J.D.I. Ltd., pers. comm.) compared to 105 000 ha treated last year.

1.2 Insecticides

Insecticides used in 1988 (Table 1) were: the chemical fenitrothion (Sumithion), and two biological insecticides containing Bacillus thuringiensis var. kurstaki (B.t.). These were Dipel 132 and Futura XLV. Approximately 51.5 percent of the program was treated with double applications of fenitrothion; 1.4 percent with a single application[1] of fenitrothion; 41.2 percent with a single application of Futura XLV and 5.8 percent received a single application of Dipel 132. In addition, three small black spruce seed production areas were treated with two applications of fenitrothion followed by one application of Futura XLV.

1.3 Operational Logistics

Forest Protection Limited was advised by the Department of Natural Resources and Energy that the first foliage protection spray blocks were biologically ready for chemical application on May 24th and spray operations commenced on that morning. Blocks were declared biologically ready for B.t. treatment starting May 27th and spraying with B.t. commenced the next day. Spray operations ceased the evening of June 13th. Three small black spruce seed production areas[2] and two small "gypsy moth blocks" were also treated by FPL and will be reported elsewhere.

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[1] *Due to minor shortage in amount of fenitrothion on hand.*
[2] *Sprayed on May 8, June 13, and June 18.*

Table 1. Areas sprayed by Forest Protection Limited for spruce budworm control in 1988 in New Brunswick*. (Does not include J.D. Irving Ltd. program).

Treatment**	Hectares Thousands	(%)	Acres Thousands	Aircraft Type
One Application - Biological				
30 BIU-D132/2.36 L/ha	26.0	(5.8)	64.0	TBM
30 BIU-FXLV/2.02 L/ha	184.5	(41.2)	456.2	DC-6, Ag Truck
SUB-TOTAL	210.5	(47.0)	520.2	
One Application - Chemical				
280 g Fen/1.46 L/ha	6.3	(1.4)	15.5	TBM
Two Applications				
210 g Fen/1.46 L/ha + 210 g Fen/1.46 L/ha	231.1	(51.5)	571.0	TBM, Ag Truck
SUB-TOTAL	237.4	(52.9)	586.5	
Three Applications (Black Spruce Seed Production Areas) 210 g Fen/1.46 L/ha + 210 g Fen/1.46 L/ha + 30 BIU-FXLV/2.02 L/ha	0.6	(0.1)	1.5	Ag Truck
GRAND TOTAL	448.5	(100.0)	1108.2	

*Source: Forest Protection Ltd.

**D132 = Dipel 132
FXLV = Futura XLV
Fen = Fenitrothion

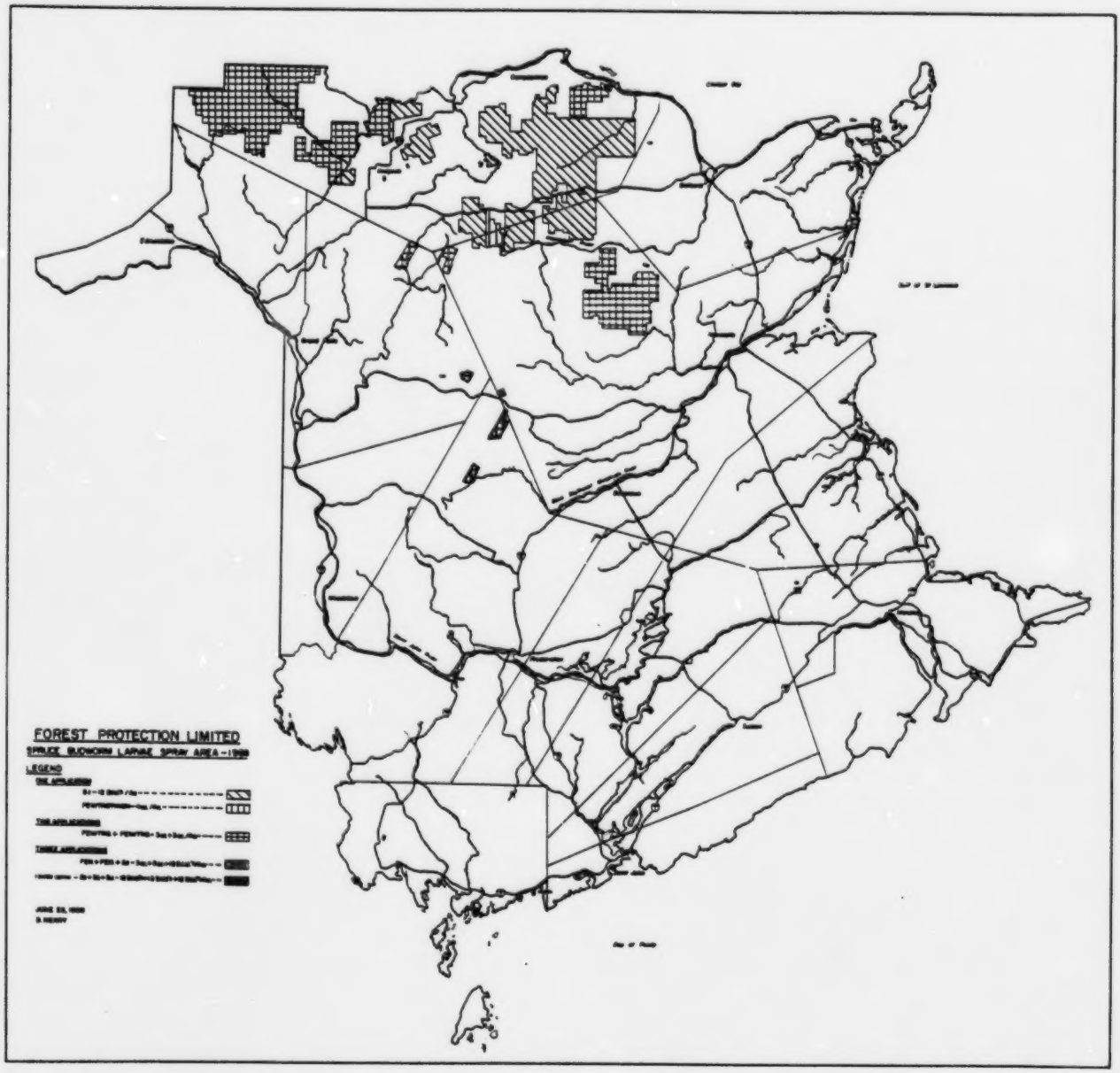

Figure 1. Areas sprayed by FPL for spruce budworm control in New Brunswick in 1988. (Does not include J.D. Irving Ltd. program).

Excellent spray weather occurred during spray operations, though mean daily temperatures were "cool" during this time as comfirmed by records of maximum and minimum temperatures available from locations distributed around the main spray areas (Appendix I). Frost damage was noticed in some areas especially on young trees in low-lying valleys or frost pockets.

All spraying was completed within a 21-day period (Appendix II). The spray period for TBM and small spray plane (SSP) chemical treatments (15-20 days) appears to be consistent with most of 1987. Spray periods ranged from 8 to 12 days for the two applications of fenitrothion, 12 days for the single TBM application, and 11 to 15 days for SSP fenitrothion treatments (Table 2). A minimum period of 5 days is required between each application of chemical as per label specifications. The spray periods for B.t. treatments (10-12 days) also appear to be consistent with 1987 results ranging from 0 to 12 days for large aircraft, and 2 to 6 days for SSP spraying.

Table 2. Spray periods associated with each treatment in 1988.

Treatment	Spray Period (days)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TBM 2xFen.									1	1	3	6	2			
TBM 1xB.t.			1	1					1							
DC-6 1xB.t.	D001 - 0 to 10 days, D002 - 11 to 12 days															
TBM 1xFen.													1			
SSP 1xB.t.			1				1		1							
SSP 2xFen.												1			1	2

1.4 Spray Costs

Table 3 provides spray costs for all treatments from 1984 to 1987 and estimated costs for 1988. Costs of aerial surveys of defoliation, the L2 forecast survey, and FPL overhead, including research and development, are not included. Final costs for 1988 are not available for inclusion in this report.

Table 3. Operational spray costs in New Brunswick from 1984 to 1987 and estimates for 1988. (Not adjusted for inflation).

Treatment	Cost ($/ha)				
	1984[a]	1985[a]	1986[a]	1987[a]	1988[b]
TBM chemical	6.80	7.23	9.19	7.07	11.20
TBM B.t.	11.79	14.12	-	12.22	12.63[c]
SSP chemical	11.52	11.82	11.50	16.42	16.98
SSP B.t.	16.38	18.71	16.60	21.54	21.30

a = actual cost, b = estimated cost, c = includes DC-6.

2. SURVEYS AND ASSESSMENTS

Various surveys were used to time spray applications and assess results of each treatment. Methods were similar to those used in previous spray programs against spruce budworm in New Brunswick.

2.1 Status of Budworm Populations

Most of the 1988 infestation was predicted to occur in northern New Brunswick, in Restigouche County and adjacent areas. The number of L2 sampling points with high and extreme populations increased from 48 in 1986 to 144 in 1987 - a 300% increase. About 90% of these high and extreme points were concentrated in the northern third of the Province. Furthermore, overwintering larval populations in Restigouche County increased an average of 15.4 L2 larvae per 75-cm branch* between 1986 and 1987. This is significant because in the forecast survey 7-20 larvae/branch indicate populations which can cause moderate defoliation, and 20+ larvae/branch indicate populations which can cause severe defoliation.

High populations that were forecasted were confirmed by numbers of pre-spray larvae obtained from samples in sprayed and control areas (Section 3.2).

2.2 Biological Criteria for Spraying

Biological criteria used in 1988 were like those used in previous years. Spray blocks were assessed from both the air and the ground before they were deemed ready for treatment. Fenitrothion blocks were deemed ready when samples of balsam fir met the following criteria:

> majority of budworm in third instar; all budworm larvae feeding in the shoots or flowers; and the shoots in Class 3 and 4 with needles on new shoots exposed or buds starting to flare (Dorais and Kettela, 1982).

B.t. blocks were deemed to be ready for treatment when balsam fir samples met the following criteria:

> majority of budworm in or beyond third instar; budworm larvae feeding in the shoots or flowers; and the shoots in Class 4 and 5 with majority of shoots starting to flare, or fully flushed.

Timing of sprays tended to follow these general criteria, but in some instances, especially B.t. blocks, spray was applied as early as possible within the spray window because budworm populations were extremely high, and defoliation had become noticeable. Furthermore, much varibility occurred in shoot and larval development in the large blocks (especially DC-6) and this variability had to be blended for optimal timing of sprays. A total of 500 development samples at 129 block-specific locations were used to time spray applications (Appendix II).

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*The standard length of branch in the L2 survey in New Brunswick is 75 cm.

Concurrent with ground observations on insect and shoot development throughout the blocks, a trained observer made regular low-level aerial reconnaissance flights to evaluate and follow the rate of shoot flushing on balsam fir and other tree species over the area. Results of aerial and ground observations were integrated to determine which blocks were ready for treatment.

2.3 Pre-spray Population Checks

To facilitate comparisons between the large-scale use of B.t. and fenitrothion, surveys of pre-spray larval population densities were conducted in transects distributed throughout both treatments and in check areas. Each transect consisted of 8 plots of 5 trees/plot and were distributed as follows: 9 transects in fenitrothion, 11 transects in B.t., and 10 transects in check areas. One of the check plots was lost due to harvesting during the program.

2.4 Post-spray Checks

Sampling was continued after spraying had commenced to monitor larval activity and progress of defoliation as well as rate of pupation. This information was used to decide whether treatment should be discontinued because of advanced larval development and feeding damage. In addition, information on pupation and cessation of feeding was used to determine when to commence the aerial survey of defoliation.

2.5 Defoliation Surveys

Estimates of percent defoliation were made on mid-crown branch samples after pupation was completed. Foliage protection in treatment areas was within objective limits if 60% or more of the current year's needles on balsam fir, and 50% or more of the current year's needles on red-black spruce were retained. Pre-spray larval counts in check plots were used to determine curves of expected defoliation. Observed branch defoliation in spray blocks was used to compare efficacy between treatments. Frost damage was not a problem in the plots which were selected for assessment.

The extent and severity of defoliation throughout the Province was surveyed from the air after the spray program was terminated and larval feeding was finished. BLOCK-SPECIFIC SURVEYS WERE NOT CONDUCTED to map defoliation in sprayed areas thereby removing observer bias.

2.6 L2 Survey

Since 1985, the overwintering larval or L2 survey has been adopted as the method of forecasting the distribution and intensity of budworm infestation for the ensuing year. Supplementary samples are collected throughout the winter months to assist in planning the protection program.

3. EFFECTIVENESS OF SPRAY OPERATIONS

3.1 Aerial Survey of Defoliation[a]

The aerial survey of defoliation provided an overview of the distribution and intensity of budworm feeding throughout the Province. Following preliminary aerial reconnaisance flights, the aerial survey commenced on July 4th and was completed on July 13th. During this 10-day period, surveying was not done on six days because visibility was too hazy. Supplementary reconnaissance flights on several more days failed to detect new areas of defoliation.

The aerial survey recorded 43 000 ha of light, 196 000 ha of moderate, and 304 000 ha of severe defoliation. The combined area of moderate and severe defoliation was 16 percent more than last year, yet 75 percent less than five years ago (Table 4). Defoliation was mainly concentrated in the northwest and north-central areas, though southern, western and central parts of the Province were largely undamaged (Figure 2).

Table 4. Areas of spruce budworm defoliation in New Brunswick from 1975-1988.

	DEFOLIATION CATEGORY (000 ha)		
Year*	Light	Moderate & Severe	Total
1975	820	3 567	4 387
1976	192	404	596
1977	123	481	604
1978	141	669	810
1979	105	1 320	1 425
1980	176	673	849
1981	135	1 221	1 356
1982	185	1 202	1 387
1983	301	2 028	2 329
1984	**	730	730
1985	**	1 071	1 071
1986	160	927	1 087
1987	88	430	518
1988	43	500	543

* Data from 1975 to 1983 from Kettela (1983).
** Light defoliation not recorded.

a. The aerial survey is a joint effort of the Department of Natural Resources and Energy, and Forestry Canada.

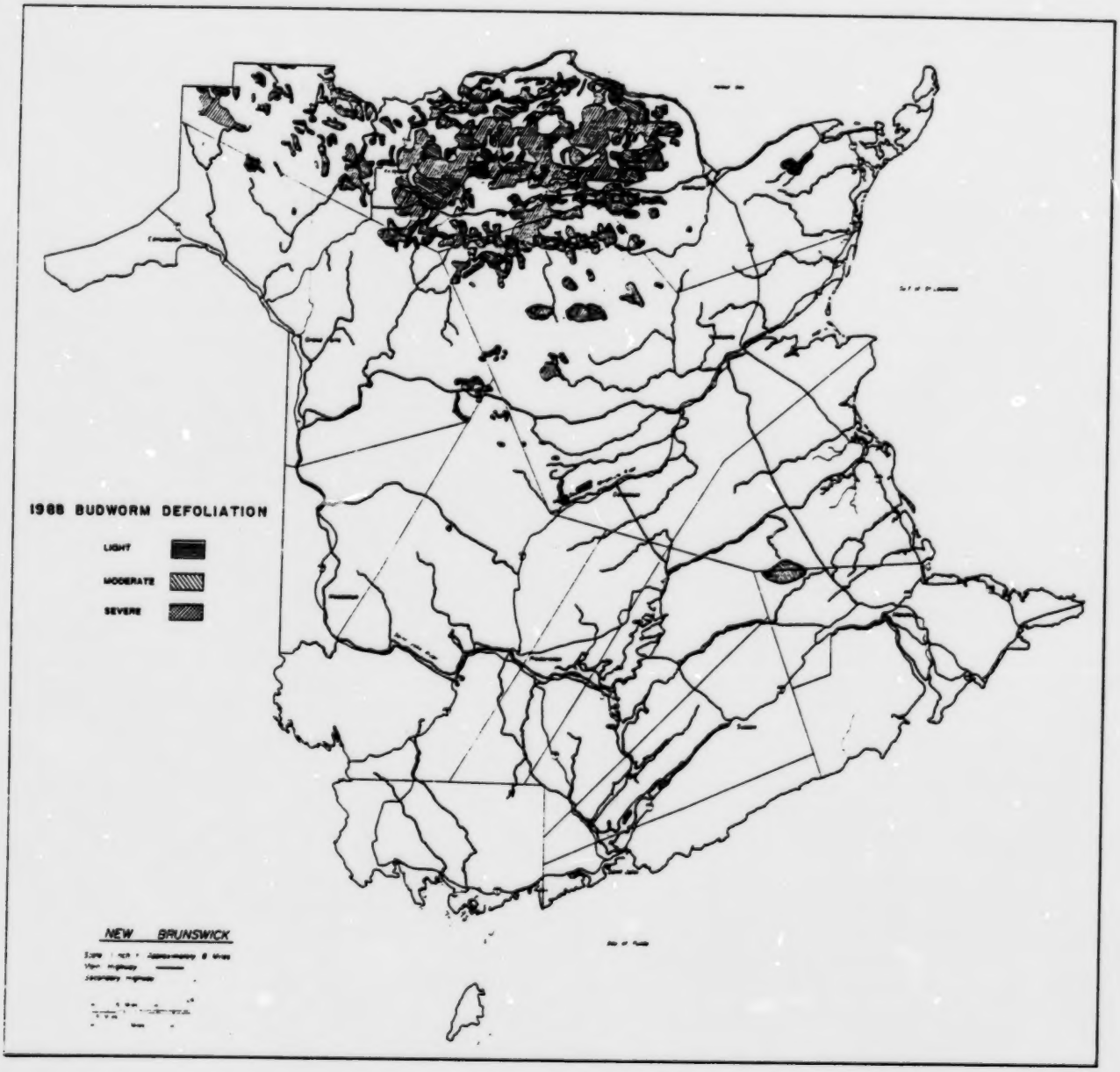

Figure 2. Areas of light, moderate and severe defoliation caused by spruce budworm in New Brunswick in 1988.

3.2 Efficacy of Treatments

Several factors influence efficacy data collected by ground or aerial surveys (Carter and Lavigne, 1988; Kettela, 1982). The stated objective for annual protection in New Brunswick is to retain 60% or more of the current year's needles on balsam fir, and 50% or more on red-black spruce. Nevertheless, when pre-spray populations are very high or extreme, a spray program might still be considered beneficial when foliage protection is less than the objective though a compliment of vegetative buds is retained for the following year.

The area of moderate and severe defoliation within all spray areas was greater for B.t. blocks (60%) than for fenitrothion blocks (19%) (Table 5). THIS WAS NOT A BLOCK-SPECIFIC SURVEY hence these results are relative rather than absolute. For the 11-year period from 1976 to 1987 the average proportion of treated area receiving moderate and severe defoliation was 14% (range 6-20%). Prior to 1985, 95-100% of the areas were sprayed with chemical insecticides.

Table 5. Area of moderate and severe defoliation within areas treated with fenitrothion or B.t. in New Brunswick in 1988.

Treatment	Area (ha) Sprayed	Area (ha) Defoliated	% of Spray Area Defoliated
FENITROTHION	237 956	45 895	19.3
B.t.	210 520	126 623	60.1
TOTALS	448 476	172 518	38.5

Pre-spray populations expressed as mean numbers of larvae per 45-cm branch tip and larvae/bud were: for check, 26.0 and 0.364; fenitrothion, 21.6 and 0.315; and B.t., 30.7 and 0.430 (Table 6).

Larval mortality caused by insecticide is not a good measure of treatment efficacy intended for foliage protection because insects can be killed after significant feeding has occurred and hence foliage protection might not be acceptable. Larval mortality at the correct time is the means to the end. Average budworm mortality caused by fenitrothion was 72%, compared to 50% for B.t. It is reasonable to expect greater levels of defoliation with lower levels of larval mortality especially when insect populations are high.

Table 6. Mean larval numbers, larval mortality, and tree defoliation on balsam fir in fenitrothion, B.t. and check plots in New Brunswick in 1988.

Block	Lines*	Aircraft	n	Pre-spray Larvae		% Mortality		Defoliation	
				Per 45-cm	Per Bud	Obs.	Corr.	Obs.%	%Red.
KEDGWICK									
Fenitrothion - 2 x 210 g/1.46 L/ha									
A-1	50-85	TBM	40	32.8	0.520	84.6	42.8	38.7	58.1
A-2	21-42	TBM	40	23.2	0.269	85.2	54.5	43.8	53.3
A-2	52-67	TBM	40	21.8	0.422	91.4	66.1	32.8	62.6
A-2	70-92	TBM	40	22.1	0.308	89.2	63.4	41.4	53.2
A-3	5-20	TBM	40	14.3	0.178	83.7	66.7	32.8	57.9
A-4	55-76	TBM	40	8.9	0.149	97.4	95.1	14.4	82.3
A-5	37-55	TBM	40	17.8	0.217	94.9	86.1	27.5	66.7
Bacillus thuringiensis									
Dipel 132 - 1 x 30 BIU/2.36 L/ha									
A-6	44-52	TBM	40	16.3	0.232	83.4	61.4	46.5	41.0
A-7	9-25	TBM	40	21.9	0.244	87.2	83.8	62.0	24.4
Futura XLV - 1 x 30 BIU/2.03 L/ha									
D-2	10-26	DC-6	40	14.2	0.235	87.8	71.6	27.4	64.4
D-2	72-90	DC-6	40	39.3	0.659	94.3	70.2	94.2	4.2
Untreated									
Check 1	-	-	35	11.1	0.189	57.5	-	56.4	-
Check 2	-	-	40	18.5	0.236	58.3	-	72.5	-
Check 3	-	-	40	19.2	0.258	63.6	-	95.9	-
Check 4	-	-	40	11.4	0.151	32.0	-	72.1	-
CAMPBELLTON									
Bacillus thuringiensis									
Futura XLV - 1 x 30 BIU/2.03 L/ha									
D-1	10-30	DC-6	40	40.8	0.603	87.2	58.4	78.9	16.8
D-1	42-65	DC-6	40	27.3	0.288	83.5	50.9	64.0	25.3
D-1	75-85	DC-6	40	45.6	0.605	88.1	61.4	69.5	25.9
D-1	95-112	DC-6	40	38.8	0.515	74.8	0.1	74.3	22.0
D-1	120-140	DC-6	40	28.6	0.383	74.3	0.0	73.9	15.0
D-1	125-145	DC-6	40	20.5	0.430	78.2	14.2	70.2	21.6
D-1	75-90	DC-6	40	45.1	0.539	91.9	73.0	91.5	3.9
Untreated									
Check 1	-	-	40	30.1	0.427	79.2	-	96.9	-
Check 2	-	-	40	30.0	0.479	73.7	-	98.1	-
Check 3	-	-	40	24.7	0.383	79.3	-	90.8	-
Check 4	-	-	40	52.8	0.753	64.8	-	99.7	-
Check 5	-	-	40	34.5	0.439	66.3	-	97.5	-
SEVOGLE									
Fenitrothion - 2 x 210 g/1.46 L/ha									
A-13	10-24	TBM	40	40.2	0.582	93.7	76.1	56.3	40.6
A-15	20-23	TBM	40	12.9	0.187	99.6	99.2	17.0	77.7
Untreated									
Check 1	-	-	40	25.5	0.307	80.6	-	60.9	-

* Portion of block that was sampled.

When treatment data were combined, mean observed defoliation was 34% for fenitrothion compared to 68% for B.t. When expressed as percent reduction in expected defoliation, the mean reduction by fenitrothion was 61% compared to 24% for B.t. Figures 3 and 4 illustrate the superior results obtained this year with fenitrothion compared to B.t.

Current defoliation estimates were made on an additional sample of 1 084 branches. These data combined with defoliation data from intensively monitored plots were used to examine the number of branches which met the foliage protection objectives (60+% on balsam fir, and 50+% on red-black spruce). The single TBM application of fenitrothion did not provide any better protection than the single TBM application of Dipel 132 (Table 7).

Table 7. Number of branches meeting objectives of 40% or less defoliation on balsam fir, and 50% or less defoliation on red-black spruce.

Treatment	Number of Branches	Mean % Defol.	% Meeting Objectives
Balsam Fir			
TBM 2 x Fenitrothion	845	30	72
TBM 1 x Fenitrothion	43	56	35
TBM 1 x B.t. (Dipel 132)	129	52	37
DC-6 1 x B.t. (Futura XLV)	533	74	18
SSP 2 x Fenitrothion	129	15	88
SSP 1 x B.t. (Dipel 132)	43	64	23
SSP 2 x Fenitrothion (JDI)*	292	15	87
Red-black Spruce			
SSP 1 x Fenitrothion (JDI)*	40	1	100

*JDI = Sprayed by J. D. Irving Ltd. on its freehold land.
Based on L2 counts in the fall of 1987 population levels were lower and hence defoliation was also expected to be lower in these areas. Pre-spray larval counts were not recorded in these blocks.

3.3 Facts About B.t. and Factors Influencing Results

Bacillus thuringiensis, or B.t., is a naturally occurring bacterium which can cause death in certain insects (Hulme et al., 1983). The material that is sprayed, however, is produced through a fermentation process by several manufacturers who provide proprietary products of comparative and/or different concentrations. Each product formulation is unique, with the exception that they presently contain the same strain of B.t. It is normal for commercial products to vary in strength by as much as plus or minus 20% or more of that stated on the label. Applied dosages are therefore "nominal". Unfortunately bioassays are costly, time-consuming, and independent testing facilities are few. It is, therefore, difficult to confirm product potency before spray operations begin, so that dosages could be adjusted if necessary.

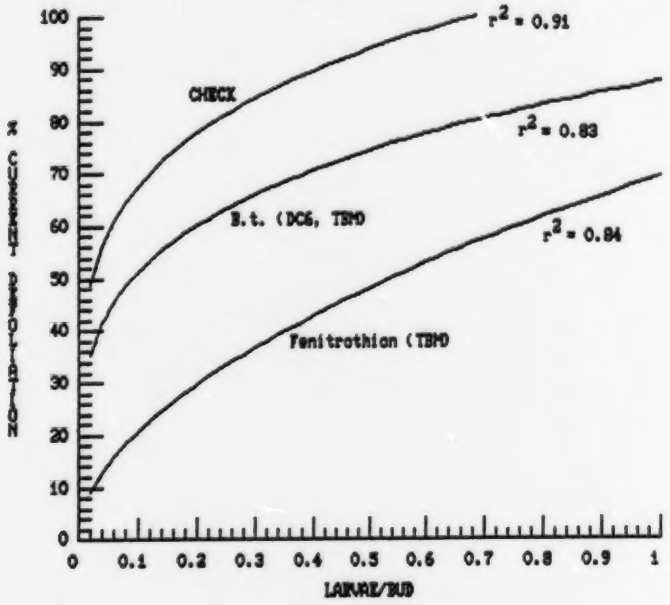

Figure 3. Percent defoliation on balsam fir as a function of pre-spray populations in treatment and check plots in New Brunswick in 1988.

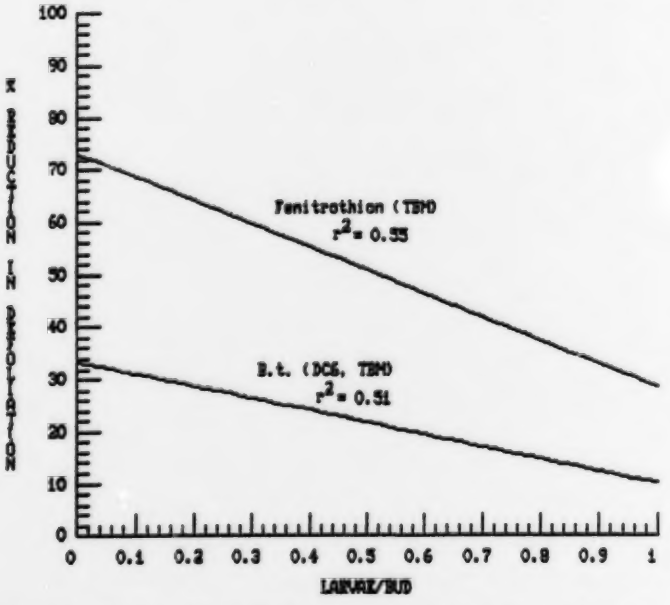

Figure 4. Percent reduction in defoliation on balsam fir as a function of pre-spray populations in plots treated with Fenitrothion and B.t. in New Brunswick in 1988.

Product quality, and more recently "contamination" by other pathogens, have become of concern for users (Irving, 1987). Permissible levels of contamination have been specified by regulatory agencies to help reduce the chances of other pathogens being present at levels unacceptable for human health. All batches sampled in New Brunswick met the required limits for 1988 as specified by Federal and Provincial regulatory agencies.

Although there are differing views on how B.t. works, it is known that it works only if eaten in sufficient quantity, and primarily by larvae of moths and butterflies. Commercial preparations contain mixtures of B.t. spores, proteinaceous crystals, various by-products of fermentation depending on manufacturer's process, plus other proprietary ingredients that make the product sprayable. Comparing the toxicity of spores and crystals, Fast (1977) concluded that "... spores play little or no role in mortality of spruce budworm induced by Bacillus thuringiensis insecticides."

B.t. is deactivated by sunlight. This tends to limit B.t.'s highest toxicity to approximately 48 hours. If sufficient B.t. is not eaten within this time, then the chances of success decline (Nigam, pers. comm.). Larvae encountering a sub-lethal dose survive, but develop at a slower rate (van Frankenhuyzen and Nystrom, 1987). B.t. has no contact toxicity. Consequently, it only has one mode of action (i.e. through ingestion). On the other hand, the chemical insecticide fenitrothion kills budworm larvae both by contact and by ingestion.

There is also a concern about the ability of currently available B.t. formulations to stick to damp foliage or be blown off damp foliage by wind, or to be washed off by rain. van Frankenhuyzen (1987) conducted laboratory tests indicating that wetness of the needle surface did not decrease retention of impinging spray droplets and that dilution of the active ingredient had no adverse effect on efficacy. He did, however, state that his conclusion should be validated in the field.

Weather can also affect B.t. results in an indirect way. Since B.t. must be eaten to be effective, the insects must be feeding. Insect activity is influenced by temperature. When temperatures are "cool", insects tend to be less active. Therefore, if "cool" temperatures follow the spray application for a few days and larval behavior is sufficiently suppressed, there is a reduced chance that a lethal dose will be eaten. Whereas ambient temperatures might be a general indicator of possible feeding conditions it need not indicate the total absence of adequate feeding conditions for at least part of the day. For instance, Wellington (1950) reported that "... at air temperatures ranging between 10 and 20°C, daytime records showed flowers ranging 2 to 5.5° above vegetative buds, which, in turn were 2 to 5° above the surrounding air." Flowers were abundant on softwood trees this year and daytime temperatures during this year's spray program were indeed within the 10 to 20°C range (Appendix I). According to van Frankenhuyzen and Nystrom (1987): "In periods of cool weather a higher droplet density might be required to ensure ingestion of an efficacious dose. However, once a lethal dose has been ingested, low temperature does not affect the level of mortality but will delay the time to death."

Furthermore, when temperatures increase after a cool spell, the residual toxicity of B.t. might have already significantly dropped due to ultra violet light or rain thereby reducing its lethality. Since temperature varies with topography (ie. elevation and aspect), these features could also influence results. In other words, small blocks with little topographical change and uniform larval and tree development might be more conducive to success, whereas large blocks with much variability can have more uncertainty for success. Previous B.t. spraying in New Brunswick has primarily been with small spray planes treating small spray blocks and lower larval populations.

Topography also influences the altitude at which the spray pilots can safely fly. This is important because spray deposit is highly influenced by spray release height and aircraft vortex strength (Irving, 1987, Appendix p. A-16). The higher the aircraft flies, the greater the chance that deposit will be reduced. Reduced deposit means lower chance of budworm encountering a lethal dose. Nevertheless, larger aircraft (such as TBM and DC-6) have greater vortex strength than smaller spray planes. Unfortunately insecticide deposit is not usually monitored in operational spray programs because of high cost and logistic difficulties. It is not known therefore whether the poor B.t. results of 1988 are more deposit related or influenced by other factors.

Large spray blocks also contain mixtures of fir and spruce as well as stands of different age classes. Fir trees flush sooner than red or black spruce, and young trees sooner than old trees. Larval development and behaviour tend to vary with tree species and phenology. Insect emergence and tree phenology vary with topography. It is, therefore, difficult to ensure "proper" large-block timing for a single B.t. (or chemical) application according to these factors. In fact, chemical insecticides have been developed as a split-application prescription to address host phenological differences and differential rates of larval development and behaviour. To date, it has been the high cost of B.t. and technological limitations which have led to the adoption of its single application. For small blocks that are few in number it is somewhat more practical to time the single application according to insect and tree conditions on the predominant host, as was done in previous programs. Spraying with small spray planes, however, is more expensive than large aircraft spraying in large operations (see Table 3).

One other circumstance which can influence spray results is the status of the infestation in which different levels of defoliation are caused by similar pre-spray larval populations. When rising or epidemic conditions occur, larval survival is high and defoliation is severe, such as in northern New Brunswick in 1988 (Figure 5). Conversely, when populations are collapsing and late larval survival is low, defoliation is also low, such as occurred in southern New Brunswick in 1987 (Figure 5). Recent operational B.t. sprays in New Brunswick have mostly taken place in areas of declining populations thereby enhancing B.t.'s apparent efficacy For example, in 1987 at a population of 0.3 larvae/bud the recorded percent reduction in defoliation was 75%, whereas in 1988 it was only 20%.

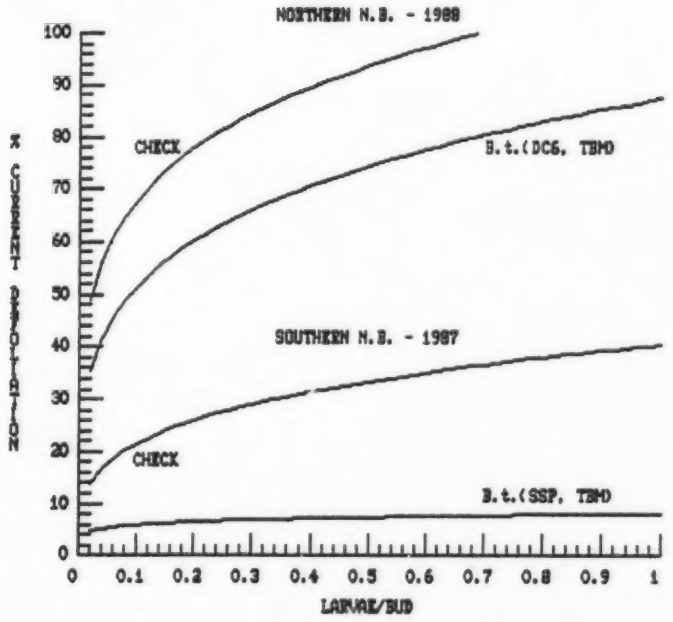

Figure 5. Changes in defoliation relationships between epidemic conditions in Northern N.B. in 1988 and declining conditions in Southern N.B. in 1987 with levels of defoliation in B.t. treated areas in both years.

In summary, many factors can contribute to an unsuccessful program with B.t. Nevertheless, with favorable conditions a single application of B.t. can and has worked. The difficulty is obtaining all these positive conditions in a large program for maximum chances of consistent success by the single application. This is not easy. It appears, therefore, that the opportunity for improving the reliable success of B.t. in the future lies in the adoption of the double (i.e. 2x30 BIU/ha) or split, (i.e. 2x15 BIU/ha) application technique as used for chemicals. Since the double application of 30 BIU/ha would double the cost of the spray material alone, greatest strides would come with more concentrated products that could be sprayed twice at, or about, 15 BIU/ha. Research with small spray planes is proving favorable in this direction (E. Kettela, pers. comm.) and the future appears to be optimistic for TBMs provided an adequate rotary atomizer can be developed, higher potency B.t. formulations registered, and the proper testing done. Forest Protection Limited is actively pursuing this technology for possible testing in 1989 (H.J. Irving, pers. comm.).

Research to improve the residual activity of B.t. by making it more resistant to rain wash-off and less prone to sunlight de-activation is also important and in progress (Anon., 1988). Finally, a better understanding of the effects of post-spray weather on efficacy, and improved weather forecasting would be beneficial.

3.4 Comparison With Quebec's 1987 and 1988 Data*

In 1987 and 1988, the Province of Quebec conducted its 18th and 19th major spray programs against spruce budworm. Areas treated were on the Gaspé Peninsula (similar topography to New Brunswick) in both years, and some on the North Shore in 1987. In both years only Dipel 132 was used. The total area sprayed was 198 000 ha in 1987, and 192 000 ha in 1988. The B.t. was applied undiluted at 30 BIU/ha using both large and small spray planes in each year.

In 1987, the program lasted from May 31 to June 18 and 90% of the area was treated between larval index of 3.0 and 5.5 (66% done between larval index of 4.1-5.0). Shoot development was generally greater than index 4.5. Weather conditions were near normal, with normal larval development except for a slow-down at the end of June between sixth instar and adult stage.

In 1988, spraying was done from June 3 to June 25, and weather was markedly colder early in June, similar to New Brunswick. Nevertheless, most areas were treated when shoots on balsam fir were well extended.

A comparison of New Brunswick's 1988 B.t. data with similar high population data from Quebec (i.e. pre-spray counts 20+ larvae/branch) in 1987 and 1988 provides some interesting similarities (Table 8). It is apparent from these data that B.t. provided inadequate protection in high populations in both jurisdictions in these three large-scale operations. If adverse weather and/or variability in timing are suspected as factors contributing to poor success in 1988, and <u>if</u> these were <u>not</u> dominant problems in Quebec in 1987, then it seems logical to suspect other factors, such as deposit and/or product longevity, especially with the single application.

Table 8. B.t. spray information from Quebec in 1987 and 1988 and New Brunswick in 1988.

	N.B.-1988	Que.-1987	Que.-1988
Spray Period	May 28-June 8	May 31-June 18	June 3-25
Area Treated (ha)	210 000	198 000	192 000
B.t. Products Used[1]	D-132/F-XLV	D-132	D-132
Dosage Applied	30 BIU/ha	30 BIU/ha	30 BIU/ha
Large Spray Planes	DC-6, TBM	DC-4	DC-4
Small Spray Planes	2 SSP	4-6 SSP	12 SSP
Number of Plots	88	40	52
Mean Pre-Spray larvae/branch	30.7	23.7	31.7
Mean Pre-Spray larvae/bud	0.43	0.36	0.33
Mean Observed % Mortality	85	91	86
Mean Corrected % Mortality[2]	50	n/a	59
Mean Expected % Defoliation	86	72	88
Mean Observed % Defoliation	68	56	71
Mean Difference in Defoliation[3]	20	16	17
Mean % Red. in Defoliation[4]	24	23	19

1. D-132 = Dipel 132; F-XLV = Futura XLV.
2. Abbott, 1925.
3. Expected-Observed.
4. [(Expected-Observed)/Expected] X 100%

*Information provided by Louis Dorais, Quebec Energy and Resources.

4. INFESTATION FORECAST FOR 1989

Changes in population intensity are detected annually in forecasting surveys (Table 9). Between 1982 and 1986 there was an increasing trend in the percent of forecast points in the Low category with a corresponding decreasing trend for the High category. In 1987, there was a three-fold increase in the proportion of points in the High category in the North-central to North-western parts of the Province. In 1988, in the same general area (i.e. Restigouche County) there was a decrease in overall mean population density (1987 = 24 L2/branch; 1988 = 14 L2/branch). Because of the known collapse of budworm populations throughout southern New Brunswick over the past few years, more than 300 points were deleted from the normal sampling throughout the area this year.

Table 9. Population changes in forecasts made in New Brunswick in the years 1981 to 1988.

		FORECAST INFESTATION LEVEL			
Year	Survey	Low	Moderate	High	Number of Points[a]
1981	egg mass	591 (34%)	441 (25%)	708 (41%)	1740
1982	egg mass	458 (26%)	512 (29%)	783 (45%)	1753
1983	egg mass	636 (48%)	257 (20%)	423 (32%)	1316
1984	egg mass/L2	747 (51%)	331 (22%)	398 (27%)	1476
1985	L2	833 (56%)	503 (32%)	185 (12%)	1521
1986	L2	1216 (77%)	322 (20%)	48 (3%)	1586
1987	L2	1198 (76%)	230 (15%)	144 (9%)	1572
1988	L2	879 (73%)	226 (19%)	99 (8%)	1204[b]

a. Does not include supplementary sampling.
b. Reduced sampling due to population collapse in southern New Brunswick.

The forecast for 1989 is for 1.653 million ha (Figure 6) of variable and moderate to high infestation, which is a 10% increase in area from last year's forecast. Variable areas are included because the mixture of low, moderate, and high points suggest patchy defoliation over smaller areas that are not well defined at the sampling intensity used for the provincial forecast. Most severe damage is again expected in the northern part of the Province with an extension to the northeast. A few pockets remain in the central area. No significant damage is expected in the southern half of the Province with the exception of one area northwest of Moncton. If the recent trend in the south continues, this area might not be as severely or extensively damaged as the L2 counts might suggest.

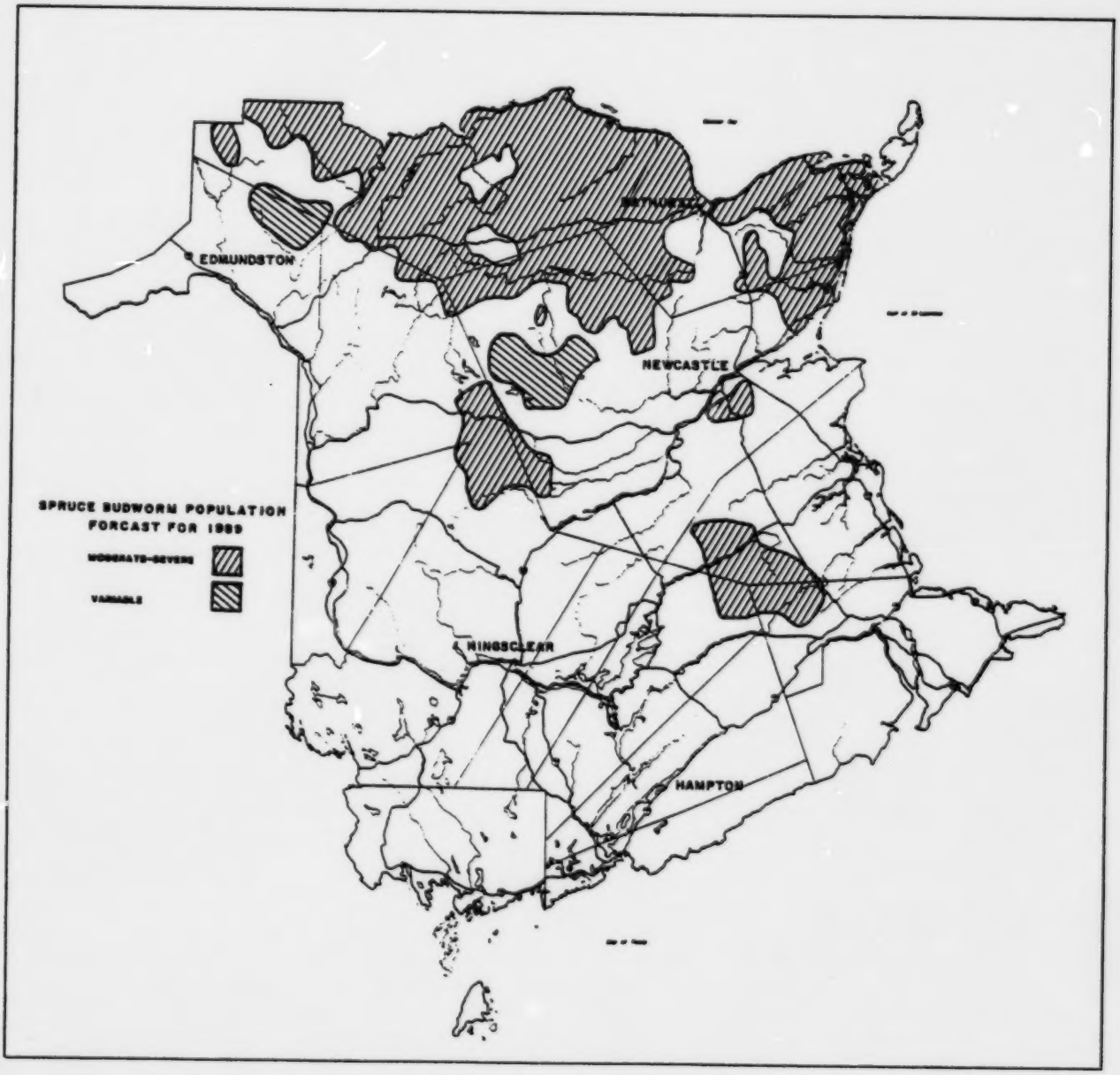

Figure 6. Areas forecast to have variable, and moderate to high infestation levels of spruce budworm in New Brunswick in 1989.

5. CONCLUSIONS

5.1 Spray Operations

1. Spray operations for 1988 with chemical and biological insecticides were completed well within the conventional time period for larval spraying.

2. No areas were left untreated due to weather delays.

5.2 Effectiveness of Program

1. Based on assessments of current defoliation on branch samples, fenitrothion provided consistently acceptable results in 1988 whereas B.t. did not.

2. Results from the aerial survey of defoliation revealed 500 000 ha of combined moderate and severe defoliation of which 34.5% fell within sprayed areas; i.e. 19.3% of the fenitrothion area, and 60.1% of the B.t. area. Of the Provincial moderate and severe defoliation 65.5% occurred outside treatment areas, but primarily within areas forecasted to be defoliated.

3. In fenitrothion plots, mean current defoliation on balsam fir branch samples was 34% compared to 68% in B.t. plots.

4. In fenitrothion plots, mean percent reduction in expected balsam fir branch defoliation was 61% compared to 24% in B.t. plots.

5. Although not a measure of efficacy, average mortality due to fenitrothion was 72% compared to 50% for B.t.

6. It is not known to what degree the poor results with B.t. were associated with deposits (not measured) or the cool weather experienced during the spray period or other factors such as insect and host variability within large spray blocks and the single application of B.t. with its single mode of action. Undoubtedly all factors contributed in varying degrees.

7. A comparison with 1987 and 1988 data from Quebec supports the conclusion that neither jurisdiction had good success with B.t. in areas of high population (20+ larvae/branch) in these years.

5.3 Forecast

1. Based on the L2 survey, a 10% increase in the area of infestation is forecast for 1989. The area forecast to have variable, and moderate to high budworm populations is 1.653 million ha. This minor increase follows the decline for the past few years. The forecast area covers about 23% of the total area of the Province.

2. An apparent decrease in population intensity within the infestation was detected by a decrease in mean L2 count for points sampled in Restigouche County this year.

3. No significant damage is expected in 1989 in the southern half of the Province or throughout most of the western and eastern areas.

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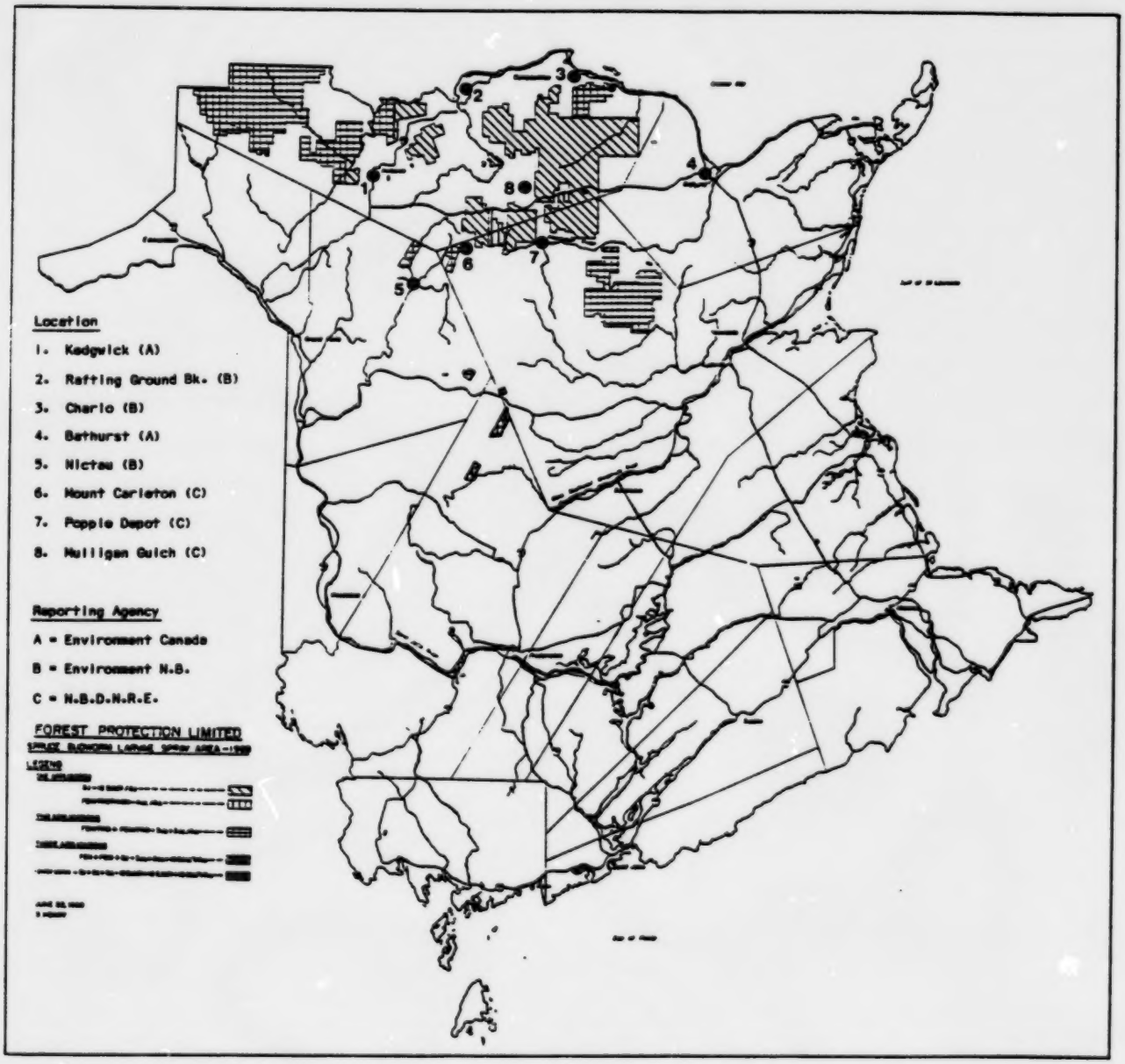
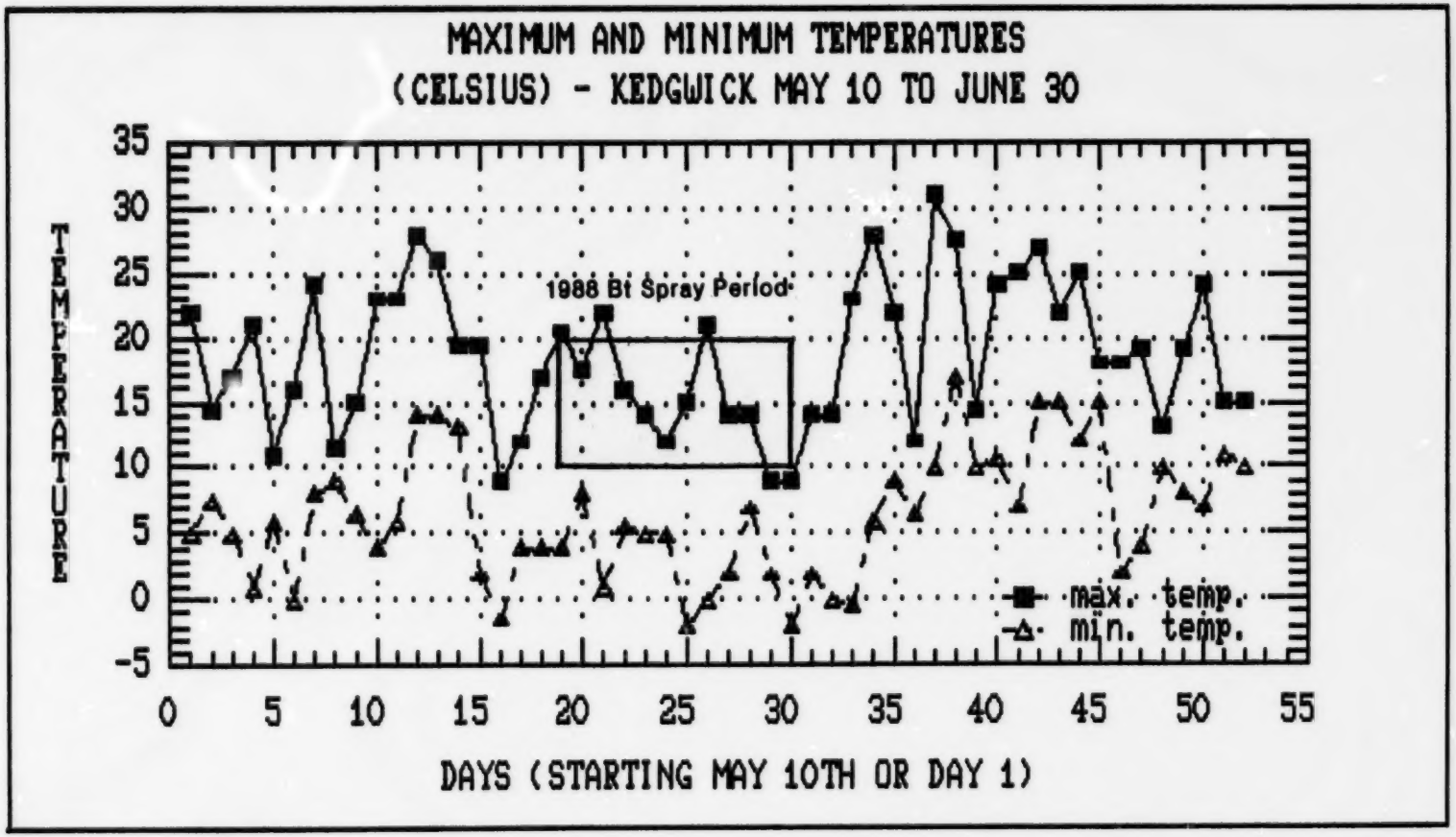
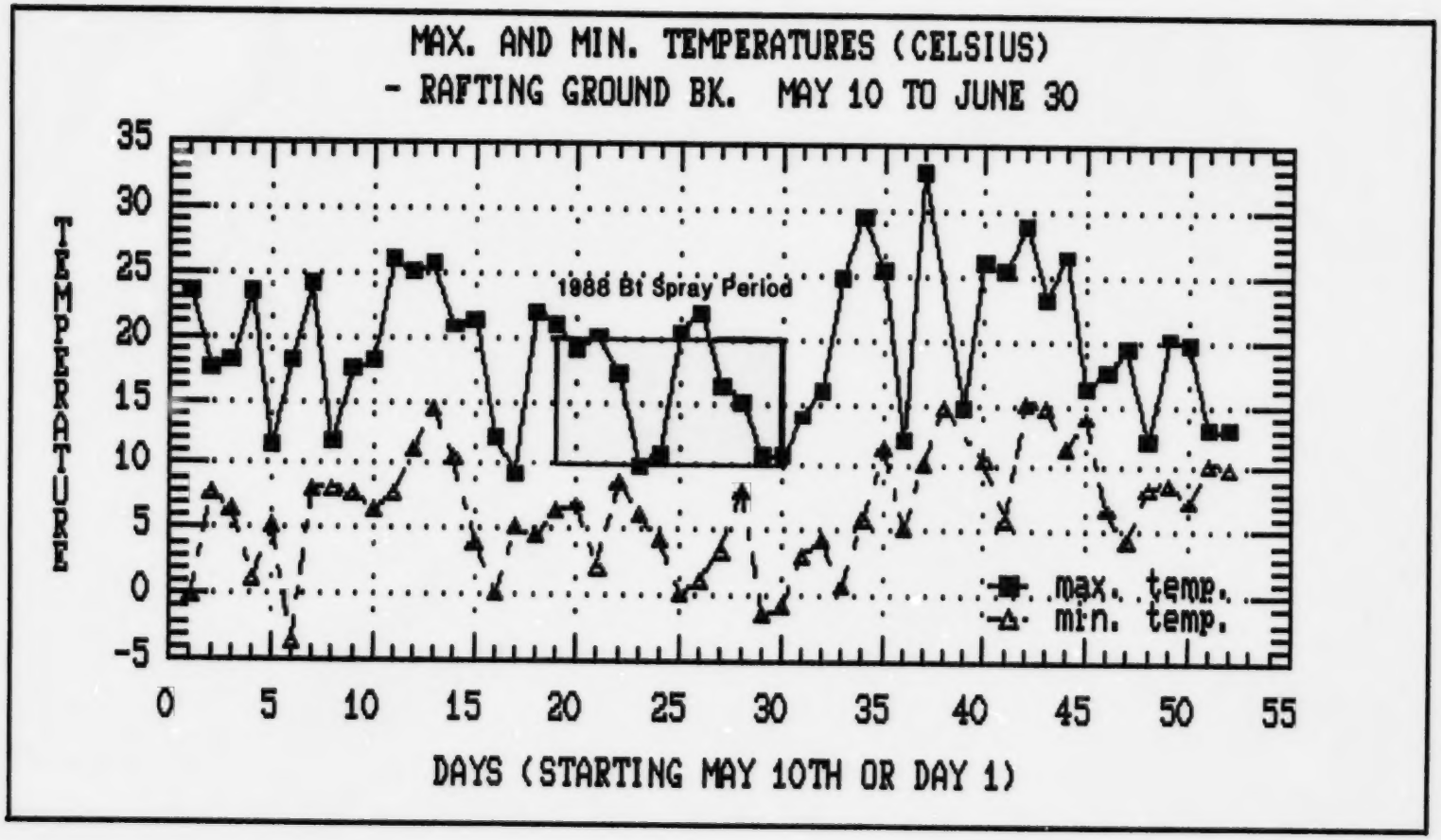
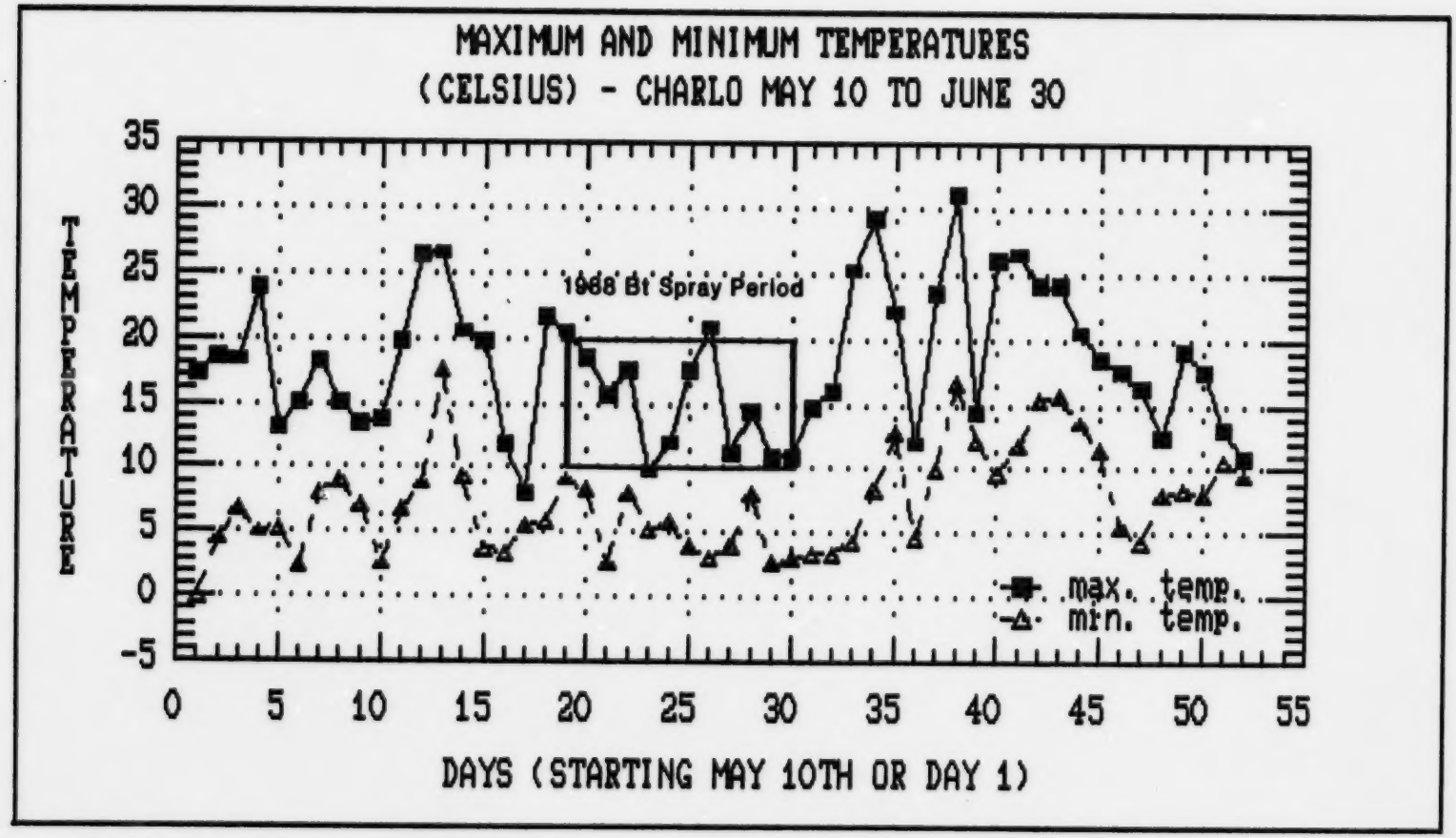
APPENDIX I

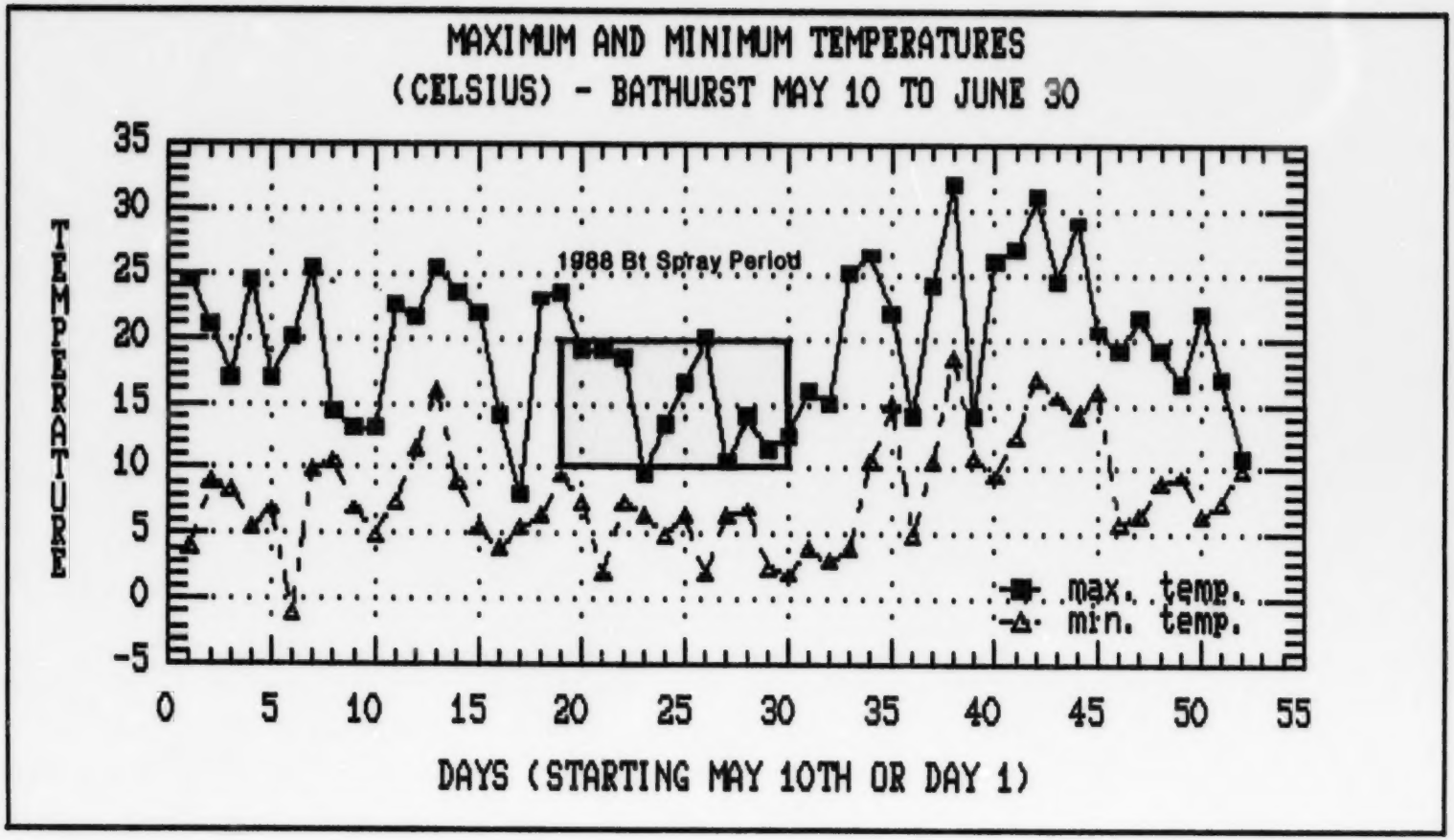


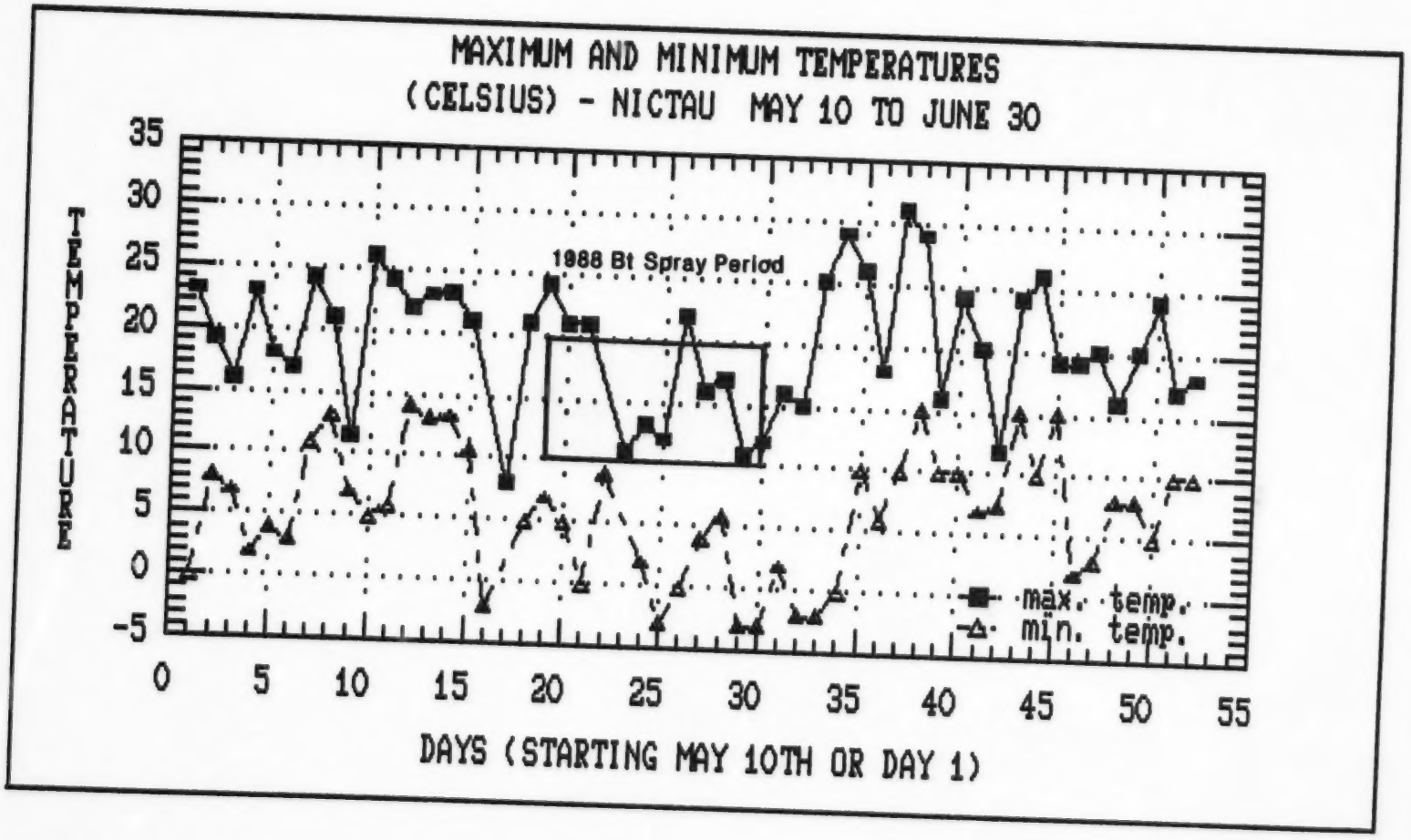
Distribution of selected weather reporting stations in relation to areas sprayed by FPL for spruce budworm control in New Brunswick in 1988. (Does not include J. D. Irving Ltd. program).

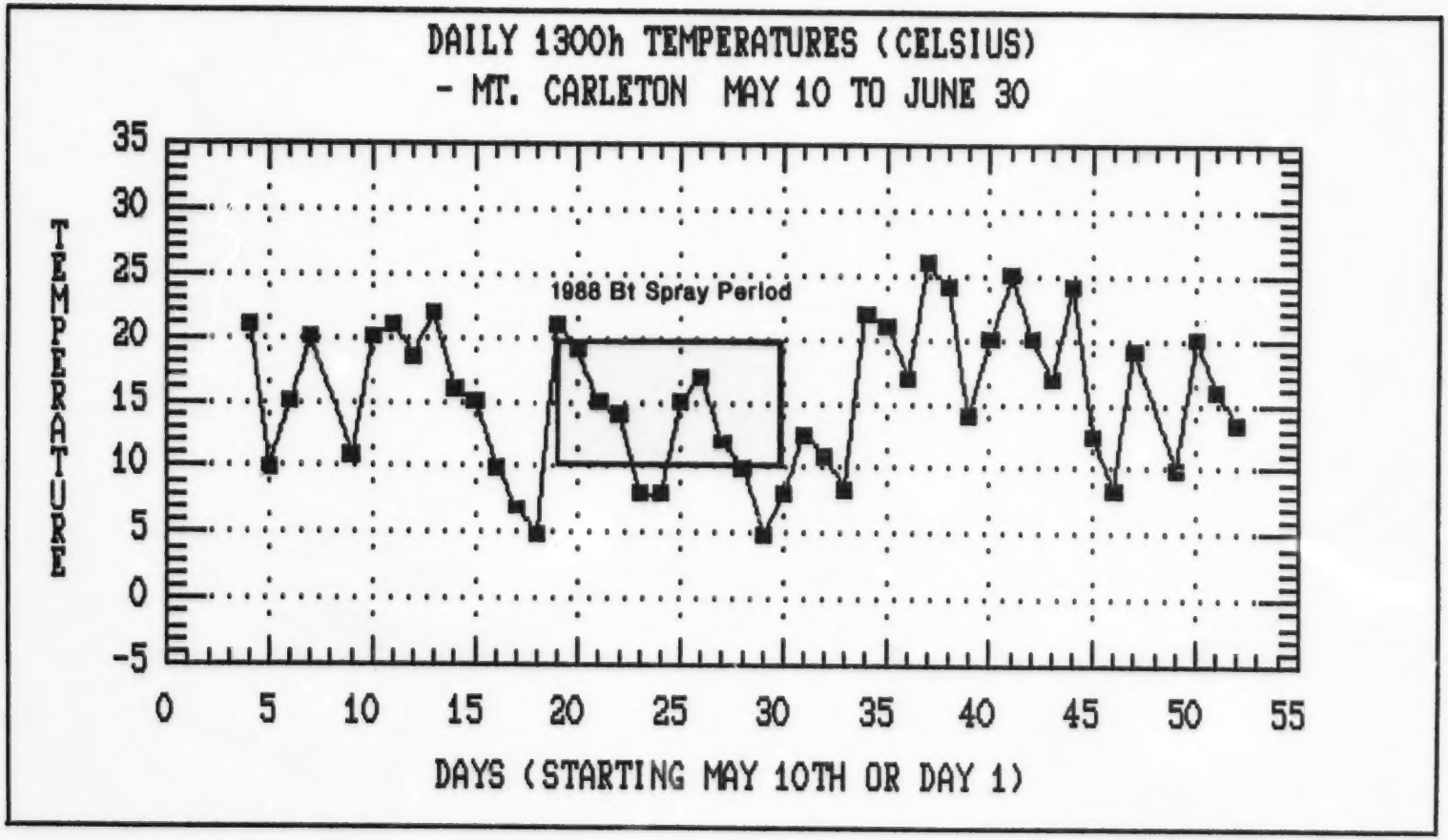

MAXIMUM AND MINIMUM TEMPERATURES
(CELSIUS) - KEDGWICK MAY 10 TO JUNE 30
TEMPERATURE
35
30
25
20
15
10
5
0
-5
1988 Bt Spray Period
max. temp.
min. temp.
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)

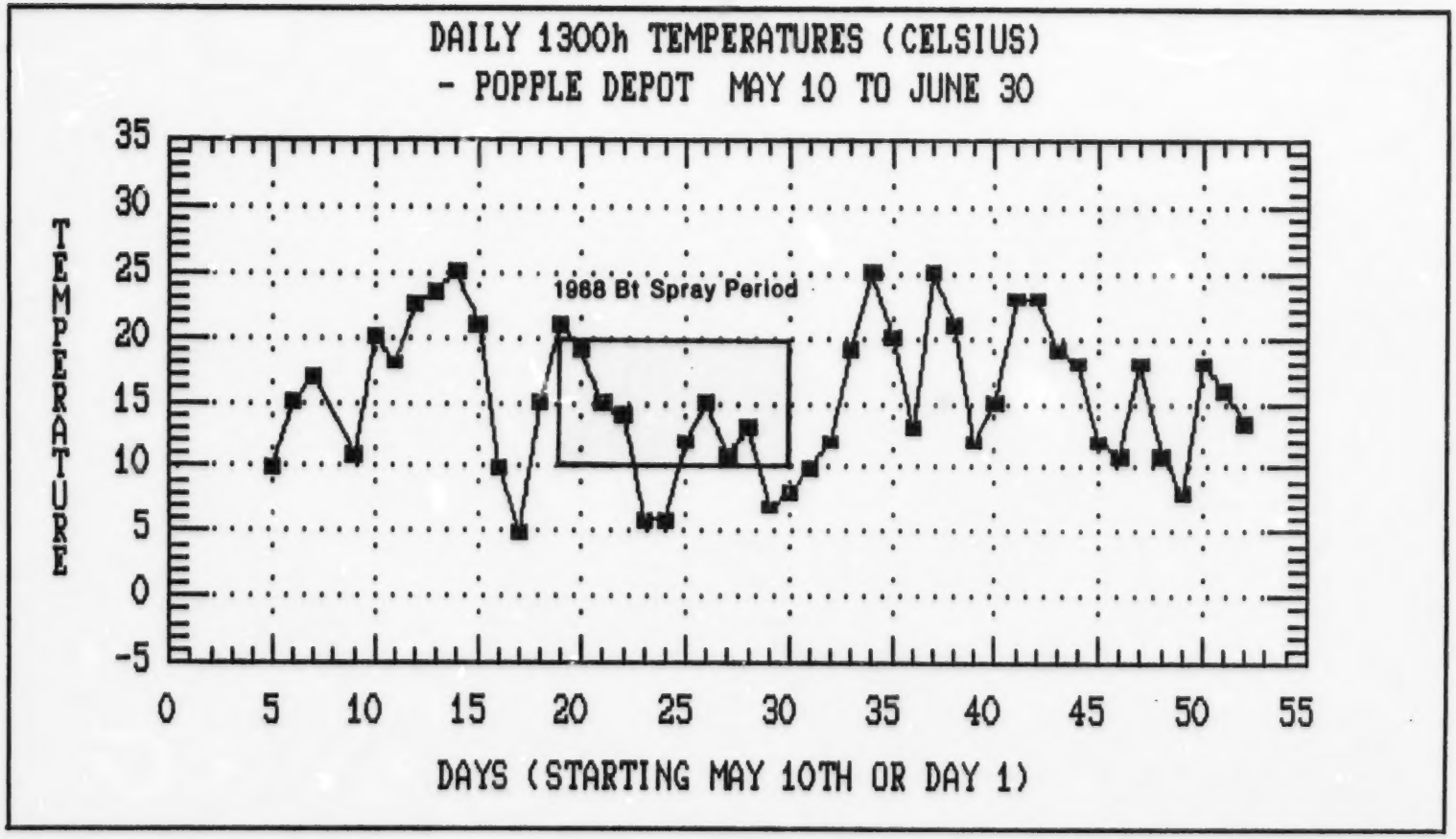

MAX. AND MIN. TEMPERATURES (CELSIUS)
- RAFTING GROUND BK. MAY 10 TO JUNE 30
TEMPERATURE
35
30
25
20
15
10
5
0
-5
1988 Bt Spray Period
max. temp.
min. temp.
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)

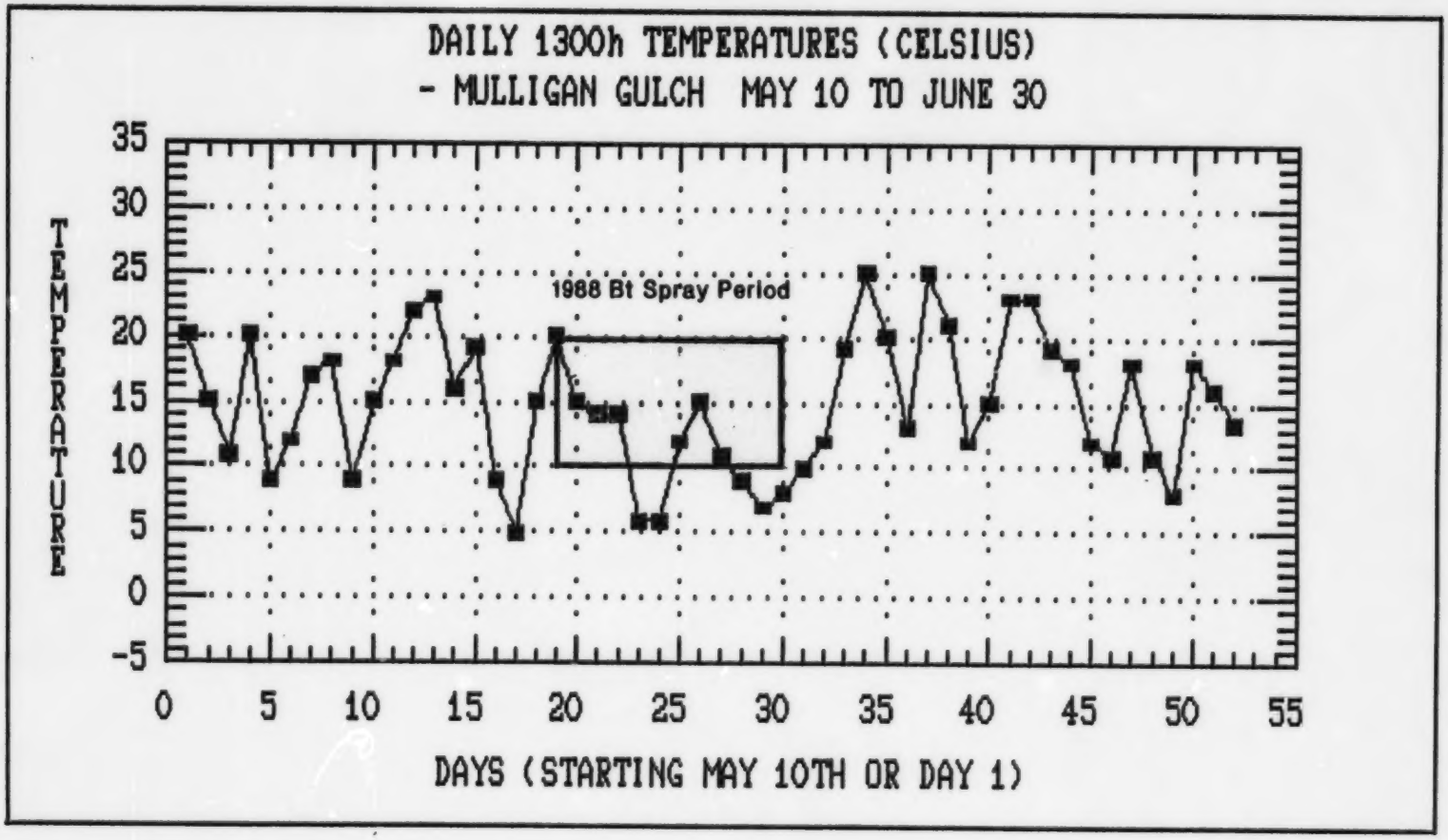

MAXIMUM AND MINIMUM TEMPERATURES
(CELSIUS) - CHARLO MAY 10 TO JUNE 30
TEMPERATURE
35
30
25
20
15
10
5
0
-5
1988 Bt Spray Period
max. temp.
min. temp.
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)


MAXIMUM AND MINIMUM TEMPERATURES
(CELSIUS) - BATHURST MAY 10 TO JUNE 30
1988 Bt Spray Period
max. temp.
min. temp.
TEMPERATURE
35
30
25
20
15
10
5
0
-5
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)


MAXIMUM AND MINIMUM TEMPERATURES
(CELSIUS) - NICTAU MAY 10 TO JUNE 30
1988 Bt Spray Period
TEMPERATURE
35
30
25
20
15
10
5
0
-5
0
5
10
15
20
25
30
35
40
45
50
55
max. temp.
min. temp.
DAYS (STARTING MAY 10TH OR DAY 1)


DAILY 1300h TEMPERATURES (CELSIUS)
- MT. CARLETON MAY 10 TO JUNE 30
1988 Bt Spray Period
TEMPERATURE
35
30
25
20
15
10
5
0
-5
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)


DAILY 1300h TEMPERATURES (CELSIUS)
- POPPLE DEPOT MAY 10 TO JUNE 30
1988 Bt Spray Period
TEMPERATURE
35
30
25
20
15
10
5
0
-5
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)


DAILY 1300h TEMPERATURES (CELSIUS)
- MULLIGAN GULCH MAY 10 TO JUNE 30
1988 Bt Spray Period
TEMPERATURE
35
30
25
20
15
10
5
0
-5
0
5
10
15
20
25
30
35
40
45
50
55
DAYS (STARTING MAY 10TH OR DAY 1)

APPENDIX II

TABLE -. Block summary of 1988 larval and shoot development information at block opening, spray history and total spray period.

Block	Treat-ment	Area Opened	Date Opened	Pheno. Cat.	No. Dev. Loc.	Tree Spec.	LARVAL DEVELOPMENT Vuln.	L.I. Range	Avg. L.I.	SHOOT DEVELOPMENT S.I. Range	Avg. S.I.	Appl.	Lines Sprayed	Date Sprayed
T-001	T2xFE	All	May 27	5W,6W	5	bF	100%	-	3.2	3.3-4.8	4.0	1st	94 1/3-123	28/05
													69 1/3-93	29/05
													46-68	30/05
													Completed	03/06
												2nd	109-120	05/06
													32-58,65-91	
													98-108,121-123	07/06
													Completed	08/06
												Spray Period = 9-12 days		
T-002	T2xFE	All	May 27	4W,5W,6W	7	bF	100%	-	3.2	3.3-4.9	4.3	1st	80 2/3-109	28/05
													57-80	29/05
													51-56,3-16	30/05
													43-50	02/06
												2nd	51-84	05/06
													0-16,43-50,	
													85-91,99-108	07/06
													Completed	08/06
												Spray Period = 9-12 days		
T-003	T2xFE	Chem. Portion	May 24	3W,4W	2	bF	100%	-	3.0	-	4.3	1st	14-20	24/05
													0-13	25/05
												2nd	11-19	02/06
													0-10,20	04/06
												Spray Period = 9-11 days		
T-003	T1xBT	B.t. Portion	May 27	3W,4W	3	bF	100%	-	-	4.8-4.9	4.8	1st	21-51	30/05
												Spray period = 3 days		

TABLE -. Cont.

Block	Treatment	Area Opened	Date Opened	Pheno. Cat.	No. Dev. Loc.	Tree Spec.	LARVAL DEVELOPMENT Vuln.	L.I. Range	Avg. L.I.	SHOOT DEVELOPMENT S.I. Range	Avg. S.I.	Appl.	Lines Sprayed	Date Sprayed
T-004	T2xFE	All	May 27	4W	3	bF	100%	-	2.9	3.2-4.7	4.0	1st	66-76	30/05
													Complete	02/06
												2nd	Complete	07/06
												*Spray	Period = 11 days*	
T-005	T2xFE	All	May 25	3W,4W	7	bF	100%	-	3.1	3.8-4.3	4.0	1st	0-9,18-32,	
													36 1/3-41, 50-59	27/05
													Complete	28/05
												2nd	0-11,57-59	02/06
													35-56	04/06
													Complete	05/06
												*Spray	Period = 8-11 days*	
T-006	T2xFE	Chem. Portion	May 24	3W,4W	4	bF	100%	-	3.1	4.1-4.6	4.5	1st	34-44	24/05
													Complete	25/05
												2nd	42-44	03/06
													35-41	04/06
													Complete	05/06
												*Spray	Period = 9-11 days*	
T-006	TlxBT	B.t. Portion	May 27	3W	1	bF	100%	-	-	-	4.4	1st	Complete	29/05
												*Spray	Period = 2 days*	
T-007	TlxBT	All	May 27	4W	4	bF	100%	-	-	4.0-4.5	4.3	1st	39 1/3-42	30/05
													0-10	02/06
													23-37,11-17	03/06
													Completed	04/06
												*Spray	Period = 3-8 days*	

TABLE -. Cont.

Block	Treat-ment	Area Opened	Date Opened	Pheno. Cat.	No. Dev. Loc.	Tree Spec.	LARVAL DEVELOPMENT Vuln.	L.I. Range	Avg. L.I.	SHOOT DEVELOPMENT S.I. Range	Avg. S.I.	Appl.	Lines Sprayed	Date Sprayed
T-009	T2xFE	All	May 25	3E,4E,5E	3	bF	100%	2.0-3.1	2.7	3.2-3.6	3.5	1st	Completed	28/05
												2nd	95-122	04/06
													Completed	05/06
												Spray Period = 10-11 days		
T-013	T2xFE	All	May 28	4E,5E	4	bF	100%	-	3.9	3.1-3.7	3.3	1st	13	29/05
													2-7,18-30	30/05
													Completed	03/06
												2nd	18-25,28-31	04/06
													2-7,26-27	28-05
													Completed	08/06
												Spray Period = 7-11 days		
T-014	T2xFE	All	May 25	3E	3	bF		-	3.5	-	3.4	1st	65-71	27/05
													Completed	28/05
												2nd	Completed	03/06
												Spray Period = 9 days		
T-015	T2xFE	East	May 25	2E,3E	2	bF	100%	-	3.2	-	3.7	1st	50-64	28/05
	T2xFE	Middle	May 26	3E,4E	2	bF	100%	-	3.3	3.2-3.8	3.5		Completed	29/05
	T2xFE	West	May 28	4E,5E	1	bF	100%	-	3.9	-	2.5			
												2nd	0-15,47-64	03/06
													16-36	04/06
													Completed	05/06
												Spray Period = 8 days		
T-017	T2xFE	All	May 24	3W	3	bF	100%	-	3.7	-	4.0	1st	Completed	24/05
												2nd	0-6	30/05
													Completed	03/06
												Spray Period = 6-10 days		

TABLE -. Cont.

Block	Treat-ment	Area Opened	Date Opened	Pheno. Cat.	No. Dev. Loc.	Tree Spec.	LARVAL DEVELOPMENT Vuln.	L.I. Range	Avg. L.I.	SHOOT DEVELOPMENT S.I. Range	Avg. S.I.	Appl.	Lines Sprayed	Date Sprayed
T-018	T2xFE	All	May 26	4W	1	bF	100%	3.0-3.2	3.1	2.7-3.3	3.2	1st	Completed	30/05
												2nd	Completed	05/06
												*Spray	Period = 6 days*	
T-019	T2xFE	All	May 24	4W	2	bF	100%	-	-	3.9-4.0	4.0	1st	Completed	24/05
												2nd	Completed	03/06
												*Spray	period = 10 days*	
				TBM TOTAL	57 development locations									
D-001	DIxBT	All	May 28	3E	1	bF	100%	-	3.0	-	3.9	1st	139,141,143,145	28/05
				4E	5	bF	100%	-	4.0	3.5-3.7	3.6		130-138,140,142,	
				5E	7	bF	100%	3.4-3.6	3.5	3.1-4.0	3.5		144,146,148,150,	
				4W	6	bF	100%	-	3.0	3.7-4.9	4.4		152,154,156,158,	
				5W	15	bF	100%	3.1-3.3	3.2	2.9-4.4	3.8		160,162,164,166,	
													168	29/05
													121-129,117,119,	
													100,102,104,106,	
													108	30/05
													Complete From	
													98-193	02/06
													75-97	03/06
													56-74,55,53,51,	
													49,47,45,43,41,	
													29,31,33,35,37,	
													39	04/06
													54-,52,50,48,46,	
													44,42,1-8,10,12,	
													14,16,18,20,22,	
													24,26,28,30,32,	

TABLE -. Cont.

Block	Treat-ment	Area Opened	Date Opened	Pheno. Cat.	No. Dev. Loc.	Tree Spec.	LARVAL DEVELOPMENT Vuln.	L.I. Range	Avg. L.I.	SHOOT DEVELOPMENT S.I. Range	Avg. S.I.	Appl.	Lines Sprayed	Date Sprayed
													34, 36, 38, 40	05/06
													9, 11, 13, 17, 19, 21, 23, 25, 27	07/06
												*Spray	Period = 0-10 days*	
D-002	TixFE	Middle	May 27	4W, 5W	1	bF	100%			-	4.0	1st	27-43	08/06
	TixBT	West	May 27	4W, 5W	2	bF	100%			3.4-4.8	4.1	1st	0-5	04/06
	DixBT	West	May 27	4W, 5W	4	bF	100%			-	4.0	1st	Completed	08/06
	DixBT	East	May 28	4W, 5W	4	bF	100%			3.2-4.0	3.6	1st	Completed	08/06
												*Spray	Period = 8-12 days*	
				DC6 TOTAL	55	development locations								
S-001	SixBT	All	May 31	3W	3	wS Plant.	100%	-	3.1	2.2-3.1	2.7	1st	Completed	05/06
												*Spray	Period = 5 days*	
S-002	SixBT	All	May 25	4W	1	bF	100%	-	3.1	-	3.3	1st	Completed	02/06
												*Spray	Period = 8 days*	
S-004	Block used for experimental purposes by CFS-M; timed by CFS-M staff.											1st	Sprayed by E.G.K. (C.F.S.-Maritimes)	
S-005	"	"	"	"	"	"	"	"				1st	Sprayed by E.G.K. (C.F.S.-Maritimes)	
S-009	SixBT	All	May 28	3E	1	bF	100%	-	3.0	-	4.0	1st	Completed	03/06
												*Spray	Period = 6 days*	
S-010	S2xFE	All	May 28	3E	1	bF	100%	-	3.5	-	3.5	1st	Completed	03/05
												2nd	Completed	08/06
												*Spray	Period = 11 days*	
S-011	S2xFE	All	May 29	4W	1	bF	100%	-	3.6	-	3.4	1st	Completed	03/06
												2nd	Completed	13/03
												*Spray	Period = 15 days*	

TABLE -. Con't.

Block	Treat-ment	Area Opened	Date Opened	Pheno. Cat.	No. Dev. Loc.	Tree Spec.	LARVAL DEVELOPMENT Vuln.	L.I. Range	Avg. L.I.	SHOOT DEVELOPMENT S.I. Range	Avg. S.I.	Appl.	Area Sprayed	Date Sprayed
S-012	S2xFE	All	May 29	4W	1	bF	100%	-	3.6	-	3.4	1st	Completed	05/06
												2nd	Completed	13/06
												Spray Period = 15 days		
S-013	S2xFE	All	May 29	4W	1	bF	100%	-	3.6	-	3.2	1st	Completed	27/06
												2nd	Completed	13/06
												Spray Period = 15 days		
S-014	S2xFE	All	May 25	3W/4W	1	bF	100%	-	3.1	-	2.9	1st	2/3 of Block Completed	28/05
												2nd	1/4 of Block Completed	07/06
												Spray Period = 13-14 days		
S-015	S1xBT	All	May 27	3W	1	bF	100%	-	3.3	-	4.5	1st	Completed	29/05
												Spray Period = 2 days		
S-016	S2xFE	All	May 8/11	1E	1	bS	20% emergence		1.0		1.0	1st	Completed	08/05
						seed	100% emergence		1.0		1.0	2nd	Completed	13/05
	S1xBT	All	June 17	1E	1	prod.	100%	4.[illegible]-4.7	4.5	2.0-3.1	2.6	3rd	Completed	18/06
S-017	S2xFE	All	May 8/11	1E	1	"	20% emergence				1.0	1st	Completed	08/05
							100% emergence					2nd	Completed	13/05
	S1xBT	All	June 17	1E	1	"	100%	-	4.7	3.0-3.1	3.0	3rd	Completed	18/06
S-018	S2xFE	All	May 8/11	1E	1	"	20% emergence				1.0	1st	Completed	08/05
							100% emergence					2nd	Completed	13/05
	S1xBT	All	June 17	1E	1	"	100%	-	4.3	2.0-2.1	2.0	3rd	Completed	18/06
S-019	S3xBT	All	May 26	GYPSY MOTH BLOCK										
S-020	S3xBT	All	May 22	GYPSY MOTH BLOCK										

SSP. TOTAL 17 development locations

Total No. Development Locations = 129